

# Lessons from the **TEVATRON** electron lenses

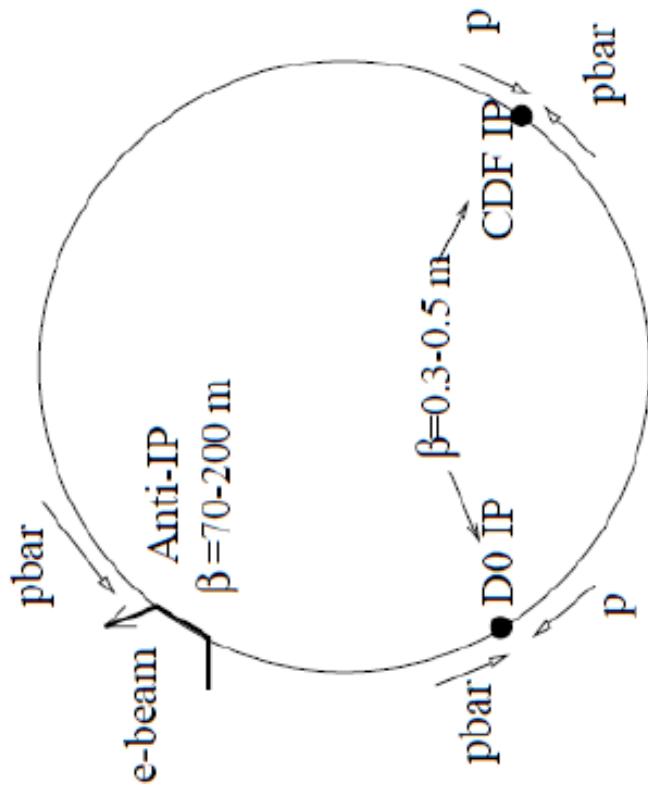
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Machine Advisory Committee, November 15 – 17, 2010

## Acknowledgments

- Learned much from TEVATRON electron lens experience (Phys. Rev. ST Accel. Beams 2:071001 (1999), Phys. Rev. Lett. 99:244801 (2007), Phys. Rev. ST Accel. Beams 11:103501 (2008), New J.Phys.10:043042 (2008))
- TEL shown to be a reliable device (no stores lost due to TEL)
- Profited from recent beam experiments performed in collaboration with A. Valishev and G. Stancari, with support by R. Moore and the TEVATRON run coordinators

## TEVATRON layout for e-lens studies



TEL2 with Gaussian cathode, pulsed to act on select pbar bunches only

Betatron phase advance between e-lens and either IP:  
 $\Delta\psi \neq 180^\circ$

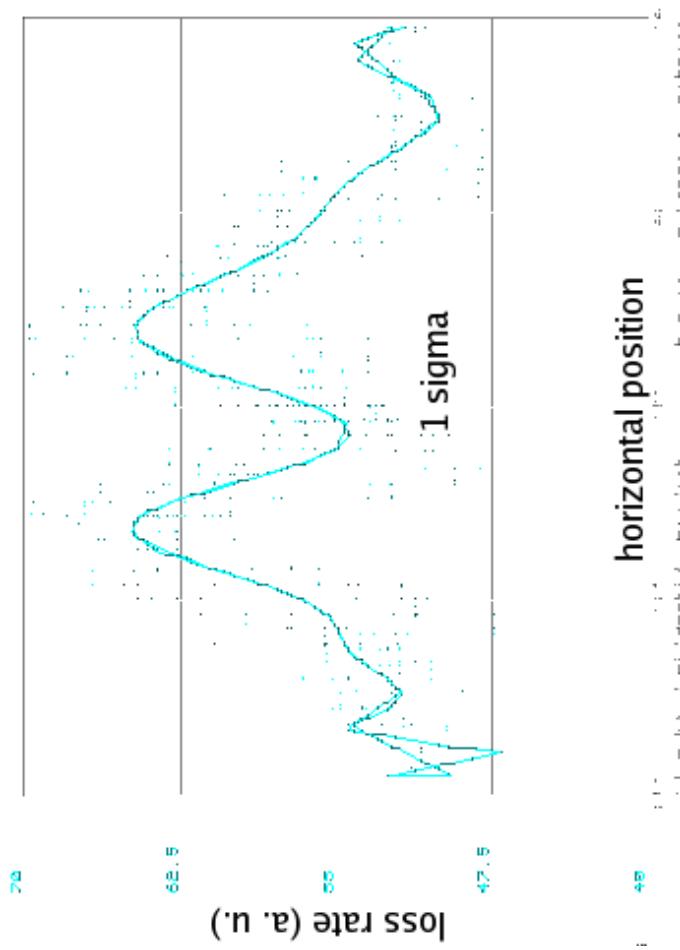
## Outline

Three types of beam studies in 2010:

- Studies with pbar only
- Parasitic studies with colliding beams,  $36 \times 36$  bunches
- Dedicated studies with  $3 \times 3$  bunches (no parasitic collisions)

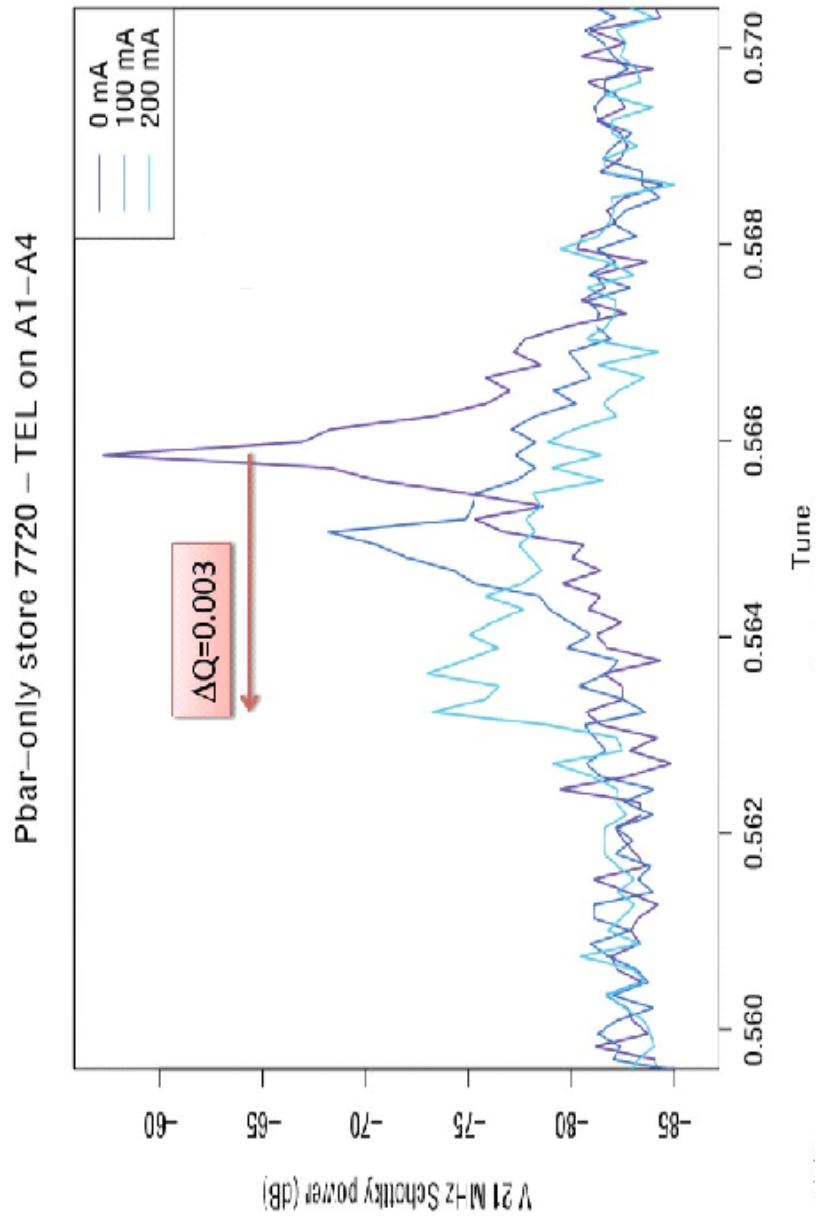
## Electron lens alignment with pbar only

Beam losses during horizontal position scan (loss monitor signal)



Alignment is critical  
Even at  $1\sigma$  misalignment, no observable intensity loss

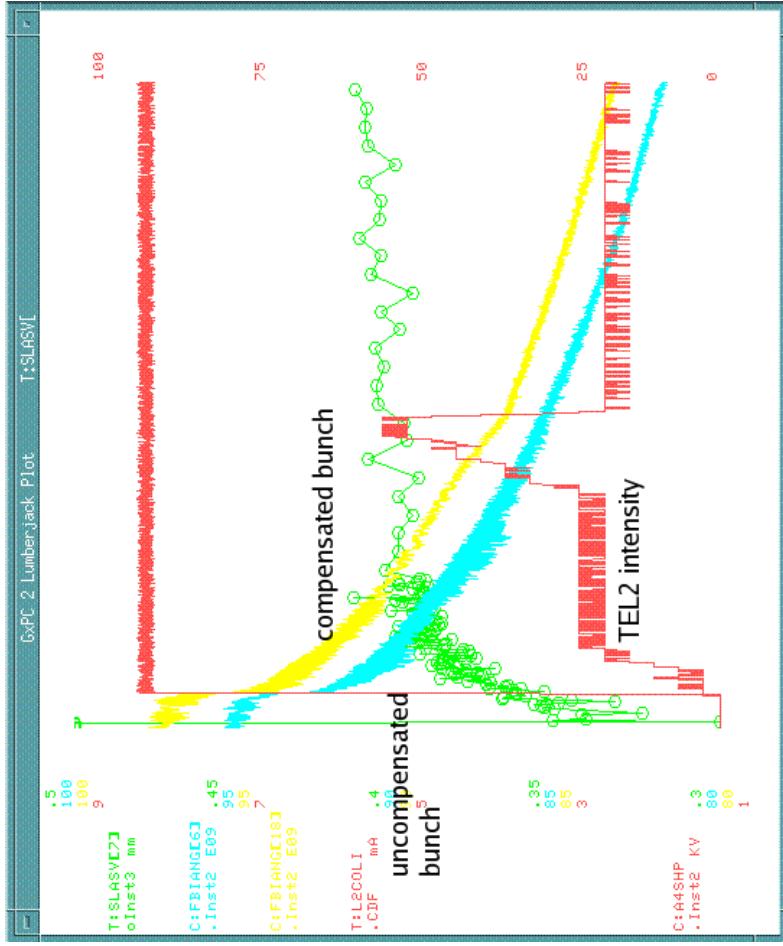
## Tune shift and spread with pbar-only



$\Delta Q = -0.003$  at  $I_{\text{peak}} = 200 \text{ mA}$ , consistent with expectations

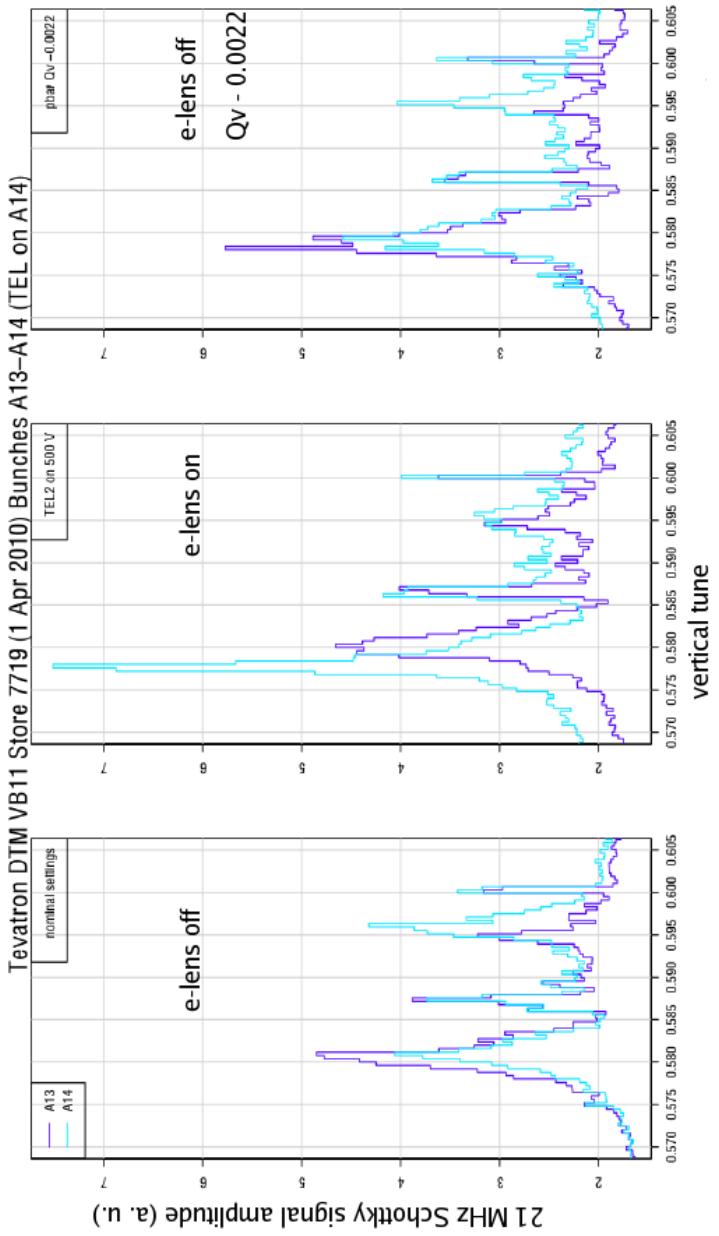
Asymmetric peaks indicate beam-beam like force

## Effect of e-lens on colliding bunch intensity



Intensity of compensated bunch suffers when e-lens pushes its tune into 7th order resonance; easily avoidable by simple tune change

## Tune measurements in collision

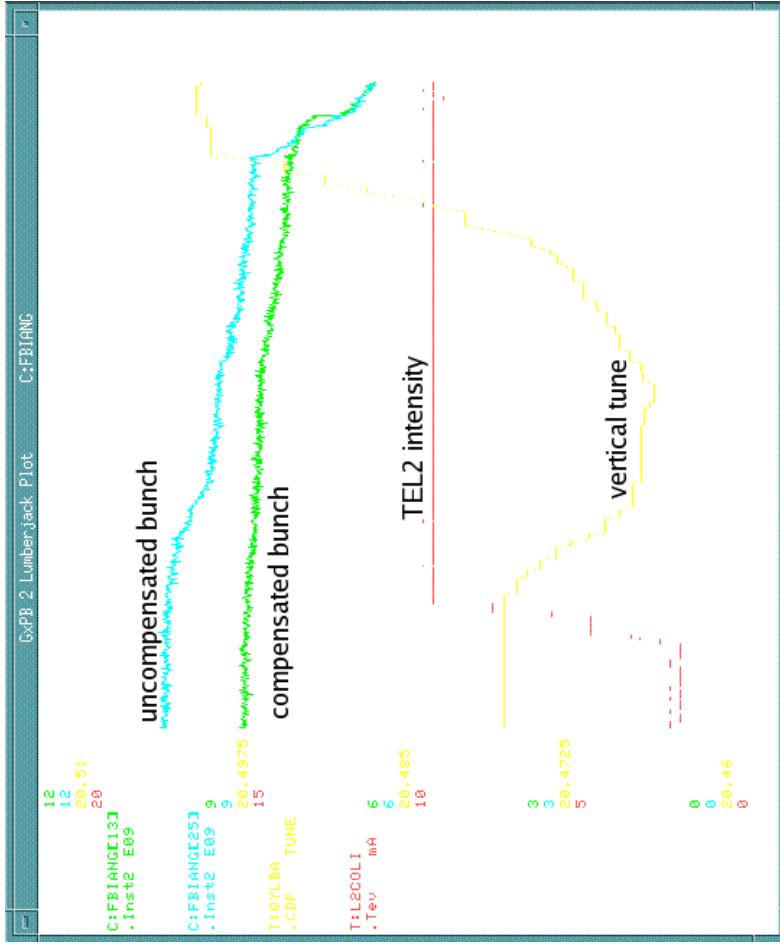


Light blue: bunch A14 (compensated)

Dark blue: bunch A13 (uncompensated)

Electron lens causes expected tune shift of  $\Delta Q = -0.003$   
(peak at 0.600 is noise)

## Vertical tune scan during $3 \times 3$ store



$$I_{\text{peak}} = 500 \text{ mA} \Rightarrow \Delta Q = -0.00075$$

No reduction of available tune space, possible signs of resonance strength reduction

## Summary

- TEL2 has worked reliably over several years, never caused any lost stores
- No measurable effect on beam lifetime even with large beam offsets at the electron lens
- Measured tune shift and spread caused by e-lens agrees with expectations

- No negative effects on lifetime of colliding bunches observable as long as low-order resonances are avoided
- Possible observation of high-order resonance compensation, though e-lens is not at the ideal location ( $\Delta\psi \neq k \cdot 180^\circ$ )